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Developing an innovative educational program for energy saving and carbon reduction: an elementary school example

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Abstract

In the education systems of human beings, the elementary education is the crucial stage for forming knowledge, attitudes, and behavior. Thus, the elementary stages of carbon reduction education will have considerable success to reduction of carbon emissions for saving the planet. In this research, the elementary school students will be taught by the teaching of energy literacy, guiding of replaced energy, developing concepts of the energy from livings, and presenting ideas. By doing so, both teacher and students will propose teaching aids modules of carbon reduction at end. This study will propose the concepts of energy-saving reduction in the innovative course through interaction between teachers and students. These concepts will be derived from existing teaching aids and energy saving productions in daily life. This research, therefore, will propose the structure of save energy and reduce carbon program, and also demonstrate some innovative concepts of students' works from this program.

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Keywords: Carbon reduction education, elementary school, innovative course, teaching aids modules;

1. Introduction

The resources available on earth have been severely depleted by the human race, resulting in many irreparable natural disasters such as the perforation of the ozone layer, an increasing sea-level caused by the greenhouse effect, andthe El Niño phenomenon of weather. These phenomena have greatly affected the residential environment of humans and also threaten the lifespan of earth. For this reason, many nations across the world are actively promoting green energy and carbon reduction. This is an environmentally friendly process intended to achieve "energy saving and carbon reduction to save Earth" using personal experience and active experimentation. Within education systems, elementary level education is a key stage in the formation of knowledge, attitude, and behavior. Therefore, energy saving and carbon reduction education at the elementary level should have an impressive effect on "energy saving and carbon reducing to save earth." In addition, elementary pupils under current energy saving and carbon reduction curricula are exposed to numerous physical and chemical phenomena. Using guided education and educational tools could help such students come to terms with environmental concepts. The perception and knowledge obtained from experiments could then be shared at home and could become practical, everyday

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applications of scientific theories. It is believed that accumulating even a small amount of power and knowledge can generate substantial results.

The research question, therefore, is how to develop an educational model for energy saving and carbon reduction, based on mutual discussion between teachers and students and energy course work combined with life-like, environmental, and scientific educational experiments. This research designed two different experimental courses for use in elementary schools. The method of question guiding is employed and centered on the teacher. The teacher plays the role of the "question guider" throughout the course of the experiment. The two designed courses involve using tangible educational tools and not using these tools. In classes with tangible tools, the core design principle was "hands-on trying." Participating students achieved interaction using experimental tools. Elementary pupils were also led to understand how energy could be produced or conserved using mechanisms commonly seen in daily life, such as hand-powered electricity generation techniques. These methods could also be related to experiences in daily life.

The results of this research employ instruction in energy literacy, guidance for alternative energy, interactions with existing teaching aids, development of concepts connecting energy to daily life, and presentations to encourage students to develop creative concepts that integrate daily life experiences. The study also uses commonly observed devices for saving and creating energy, and develops teaching aids for energy saving and carbon reduction. This research, therefore, will produce a creative guidance course for energy saving and carbon reduction education of elementary school pupils. We will also compare the difference of conceptual results obtained from the students after using and not using tangible teaching aids.

2. Related works

2.1. Problem-based learning (PBL) model

A problem-based learning model was first introduced in medical schools. This method was used to strengthen medical students' knowledge of their field of study by attaining new knowledge or correcting old knowledge while analyzing individual patient cases. The concept consisted of four facets, namely: (1) application of professional knowledge, (2) establishing a target, (3) problem solving, and (4) evaluation. Minor adjustments affected in the process of the PBL would enable its appropriate use in other areas. Currently, increasingly more academic fields have been using this system to help students engage in self-study while considering various problems.

The present method of PBL involves dividing a group into three sections, from small to large; namely, the individual, smaller sub-groups, and groups. At the first stage, the pupil must independently accomplish tasks. Through self-learning activities and research training, the student can develop the personal ability to define a particular problem. Techniques or methodologies used in problem solving will also be honed. Stage 2 entails discussions and brain-storming among members of the subgroup to nurture communication skills and cooperativeness. The activities of this stage are also intended to develop camaraderie among the members. Stage 3 involves preparing a final report of the research or discussion results. This process trains the team members in verbal expressive ability for public speaking, as well as the ability to prepare information. It also trains the team's responsive ability regarding listeners' questions and doubts concerning the contents of the presentation. The characteristics of PBL are as follows:

1. Actual problems are used at the starting point of learning;
2. The problem must connect the perception and professional knowledge of the learning target;
3. Learning progresses within a small group;
4. The learning method is self-directional;
5. The teacher or expert plays a supportive (rather than a leading) role.

The purpose of PBL could be explained from numerous perspectives. Barrows and Tamblyn (1980) defined PBL as a process of study initiated by the learner in an effort to determine a method for understanding or resolving a problem. Applying a classic PBL involves exposing the student to a problem and demonstrating the problem scenario, members utilizing their knowledge and deductive skills to begin problem solving, students initiating confirmation of study content and inducement of individualized research, utilizing the knowledge and skills obtained during the process for problem solving, and presenting and evaluating the study results. Some academics regard PBL as a course model designed with real world problems at the center (Fogarty, 1997). Others believe that PBL is a type of experiential learning revolving around chaotic, real-world problems with the investigation and solution of these problems as the central focus, whereas some deem it a curriculum organizer as well a teaching strategy (Trop & Sage, 2002). Some people also claim that the PBL is not only a study method but also a description of the entire teaching and learning process (Walton & Matthews, 1989). Although most academics consider PBL as a type of direct teaching method, Barrows indicated that PBL does not refer to any type of fixed teaching method. The purpose of PBL differs according to the teaching design and relevant teaching abilities of the individual teacher.

The purpose of PBL assessment is for instructors to demonstrate the ability of the student, provide feedback for the student, and obtain feedback regarding the effectiveness of the course (Glasgow, 1997). Assessment is not an accessory of learning and should be incorporated into the process of PBL teaching and used as a quintessential component in inducing the entire learning process. The purpose of the realistic ongoing assessment or embedded assessment implemented simultaneously with teaching and learning is in demonstrating and recording the performance of the student during the learning process. Feedback can then be supplied to the student and teacher for any necessary adjustments in teaching or learning (Delisle, 1997; Stepien et al., 1993; Trop & Sage, 2002). Many previous studies have separated PBL assessment into three main categories depending on the area of assessment: "content", "process", and "results." Assessing "content" involves focusing on the information and knowledge in the student's memory, recollection, or association. Assessing "process" entails focusing on methodology and technique. The focus of assessment includes whether the learner can establish a problem-solving structure, as well as the ability of the learner to assess information and data and use them in problem solving. The communicative skills within the subgroup, as well as acceptance of learning responsibility, were all assessed. Assessing "results" refers to measuring intelligence or specific products. A formulated standard designed beforehand was used to assess the students' effectiveness in understanding the problem, as well as their success or failure in problem-solving (Barrows & Tamblyn, 1980; Glasgow, 1997; Swanson, Case, & van der Vleuten, 1991). Some academics have further divided assessment into different modes, depending on the executor of assessment: self-assessment, peer assessment, and assessment by the teacher. Factors such as the student's logical ability, problem-solving ability, independent research ability, subgroup cooperation, and communicative abilities could be assessed according to these three types of executors (Barrows, 1985; Barrows & Tamblyn, 1980; Walton & Matthews, 1989). Regardless of the field or executor of assessment, each previous study has recommended using a multitude of assessment methods. The more process-oriented assessment methods include teacher assessment, peer assessment, self-assessment, oral assessment, practical problem simulation, problem logs, realistic assessment, and performance assessment (Barrows & Tamblyn, 1980; Gallagher et al., 1995; Swanson, Case, & van der Vleuten, 1991). The more result-oriented assessment methods include objective testing, dissertation-type examination, practical problem solving, portfolio assessment, demonstration, experiment execution, diaries, community gatherings or town hall meetings, verbal reporting, and assessment of the final items produced (Glasgow, 1997; Ram, 1999; Swanson, Case, & van der Vleuten, 1991).

2.2. Theory of creativity development

According to data from researched literature, Hite Doku defined creativity as "a means to materialize creation," which is also the definition of creativity development. Creativity is "the thought process used to achieve a goal or solve a problem"; that is, the process of actively considering and solving a problem when the need arises. Creativity development entails the recommendations or opinions resulting from a brainstorming session.

The source of creativity originates from all directions. A learner could begin with observations of daily living, such as inventing the electric fly swatter. A learner could also obtain new ideas for creativity from history, technology, literature, or even failure. The company most deserving of high praise for its creative thinking is the American company 3M, who serve as an effective reference for utilizing creativity. 3Mcelebrates failed products.

When new company products fail, 3M maintains its creativity and continues thinking, or even retains the actual product itself. In the future, when 3M requires development of another product, the failed product could be unearthed, perhaps to become a new product.

On the LifeMBA website, the mode of thinking during development of creativity is further analyzed. Many people consider creativity to be a talent. In fact, when conceptualizing a single creative idea, a set of guidelines can be followed. Presently, creative development is used in areas such as art and design. The art industry (e.g., Franz Collection Inc.) applies methods to inspire creativity and promote employees' opinions and ideas in designing products. Nanzih Primary School in Kaohsiung City in Taiwan has also used creative development in its creativity educational programs.

3. Methodologies

By interacting with the currently available teaching aids in combination with commonly seen energy saving and producing equipment, the teacher and students could mutually develop a concept for teaching aids in energy saving and carbon reduction. This method facilitates achieving the aim of this experiment, in addition to incorporating problem-based learning. The elementary education population could thus understand energy created or conserved using different methods as well as the correlations between these methods and their daily life. Therefore, the methodologies in this research can be divided into energy saving and carbon reduction education, concept guidance, and concept presentation.

1. Energy saving and carbon reduction education: factors in this section include pre-course assessment of energy literacy and explanatory courses. By delivering a power-point presentation, science teachers should conduct an assessment on energy literacy before the course to gauge the pupils' knowledge, attitude, and behavior regarding energy.

2. Concept guidance: involves using relevant videos and pictures to encourage students to use their imagination to develop possible energy transfer methods for producing electricity. At this stage, the class was divided into two groups. The experimental group was provided with operation of energy teaching aids (for instance, water-powered, wind-powered, manually powered, and solar-powered aids) in a stage fashion. The control group was not provided with any operational teaching aids. The differences between the two groups were compared.

3. Concept presentation: the third stage entails concept presentation to instruct pupils in presenting detailed concepts that they were unable to express graphically. An energy literacy assessment was performed after completing the course to determine if any differences were apparent in the pupils' energy literacy following this educational experiment.

Table 1 the structure of innovative educational program for energy saving and carbon reduction

Stages of experiment	Experimental Group (4A)	Control Group (4B)
0.Pre-course assessment questionnaire	Pre-course assessment	Pre-course assessment
1. Energy saving and carbon reduction education (90 min)	Pictorial and video education	Pictorial, video, and tangible aids education
2. Concept guidance(90 min)	Pictorial and video guidance and content description	Guidance for the tangible teaching aids and content description
3. Student reporting and post-assessment (90 min)	Reports were scanned into a power-point format, students reported for 4 min, includes teacher recommendations	

3.1. Research Material

Energy literacy course: two sections were included, earth's dangers and earth's alternatives. The earth's dangers section contained issues such as the soon-to-be depleted resources on earth and environmental problems caused by using fossil fuels. Earth's alternative section contained topics of resource conservation and renewable resources. Students must first be led to understand the general situation of earth's environment as well as the basic principles of energy. Students should be encouraged to protect earth in everyday life.

Concept guidance course: the electricity generating principles of commonly seen devices such as wind generators, water generators, wave generators, and tide generators as seen in nature are introduced. Next, commonly seen power generation sources such as revolving doors, man-powered bicycles, mills, rocking chairs, and manual operations used in daily life were observed. The students are made to discover that, in life, anything that can move is capable of generating or being transferred to electricity. The student's imagination and creativity are then incited in a gradual process.

3.2. Experimental participants

The experimental participants were fourth grade pupils from the Affiliated Elementary School of Tunghai University. Pupils in the fourth grade should demonstrate at least a basic conceptual knowledge of energy. They were subjected to the energy literacy course and creative guidance course. The differences before and after the experiment were verified by performing assessments prior to and subsequent to completing the course.

4. Process of teaching experiments

4.1. Energy saving and carbon reduction education

The energy saving and carbon reduction education course included an energy literacy pre-course assessment and an explanatory course conducted by science teachers at the Affiliated Elementary School of Tunghai University. The pre-course assessment of energy literacy was conducted before the start of the course to gauge the students' knowledge, attitude, and behavior towards energy. The first part of the course content involved discussing the resources on earth that are close to depletion. The second part involved discussing environmental problems caused by using fossil fuels. In the third part, emphasis is made on what students can do for the future. Students were introduced to renewable energy that is commonly seen in daily life as well as easily observed phenomena. All of the above were used to strengthen the students' knowledge and concepts of energy saving and carbon reduction.

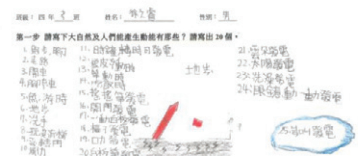
4.2. Concept development guidance

The purpose of concept guidance is to stimulate and incite the imagination of students to transform kinetic energy in daily life into electrical energy and to conceptualize their designs. Therefore, during the concept guidance process, the principles of more commonly seen electrical generators powered by nature, such as wind generators, water generators, wave generators, and tidal generators, were first introduced. Next, generators that create power in daily life, such as revolving doors, man-powered bicycles, mills, rocking chairs, and manually powered operations, were introduced. Students were led to discover that, in life, anything that moves can generate or be transformed into electricity. Finally, IDEO videos were used to incite the student's imagination and creativity. The purpose of the content was for students to utilize any movable action in daily life and transform the kinetic energy into electrical energy for storage in battery cells. In the end, the batteries were collected for use. The aims at each stage during the process of concept guidance are listed in the table 2.

4.3. Presentation of results

Fourth grade pupils must verbally describe their own concept motivation, design uniqueness, and operation method. Because of the young age of the experimental participants, their verbal descriptions might be incomplete. The science teacher must then employ leading questions and allow other students to ask questions. After completing the course, a post-course energy literacy assessment survey was conducted with questionnaires to determine the difference in energy literacy before and after the course in this experiment.

Table 2. Teaching and experimental process

Stages	Aim	Pictures
Development Guidance	Gradual motivation by video of the student's imagination and creativity.	
Step 1	Ask the students to think of 20 things in nature or human life that can move.	
Step 2	List 5 possible methods of transforming kinetic energy into electrical energy and explain how.	
Step 3	Select one or two of the proposals and sketch the concept with explanatory captions.	

5. Results and analysis

After the course design and execution of this experiment, the data collected included pre- and post-course assessment questionnaires of the students, as well as results of the concept development. Results of the questionnaires revealed that in both classes, the pre- and post-course assessment showed no significant difference. A possible explanation might be that the students had different comprehension levels regarding the questions. The teaching content for all three sections presented no significant differences to the students' daily lives. Therefore, the focus of analysis at this stage was on discussions of the concepts developed by the students. The difference in concepts developed between students using or not using tangible teaching aids was compared.

5.1. Results from the class-4A not using tangible teaching aids

Class 4A did not utilize any teaching aids during their courses. Students were more unfamiliar with transforming electrical energy and related mechanisms. Therefore, most of the concepts were theoretical and little of the structure for proposed ideas was observed (Fig 1); for example, one student believed that the kinetic energy of kicking a soccer ball could be transformed into electrical energy that could be applied to computers, televisions, and other household electrical appliances. However, the student could only demonstrate the concept in theory (Fig 1, left). Another student considered utilizing the kinetic energy caused by vibrations while walking to store electricity. Because the students were taught using only pictures and videos, they were only able to demonstrate concepts pictorially and were unable to speculate on the details of how to transform kinetic energy and store it as electrical energy (Fig 1, right).

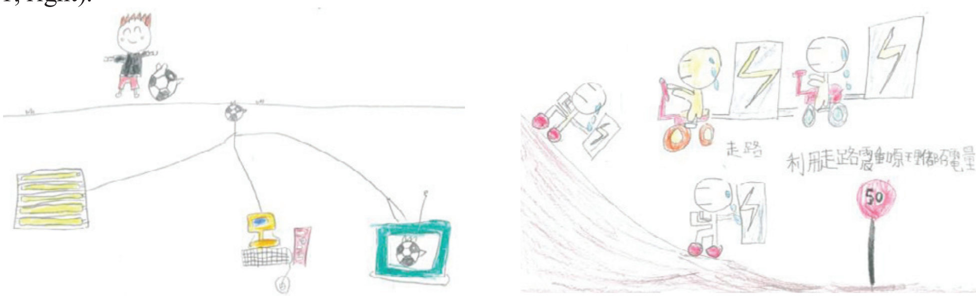


Figure 1. Results of concept development from the class-4A not using tangible teaching aids

5.2. Results from the class-4B using tangible teaching aids

Conversely, after analyzing the concept results of Class 4B using tangible aids, classes using teaching aids during the energy saving and carbon reduction courses would consider the mechanics of electrical transformation, storage, and use during concept development. One student pondered utilizing the steam created after heating water to power the rotation of an axis, thus rotating magnetic poles to generate electricity (Fig. 2, left). The student also clearly understood that electricity had a positive and a negative pole, demonstrated with red and blue colors, respectively. Another student considered using manually applied pressure to operate a pump-like object. By moving the gears in the middle, kinetic energy could be transformed into electrical energy. Students clearly understood the shape of gears and the principle that rotation energy can be transformed into electrical energy.

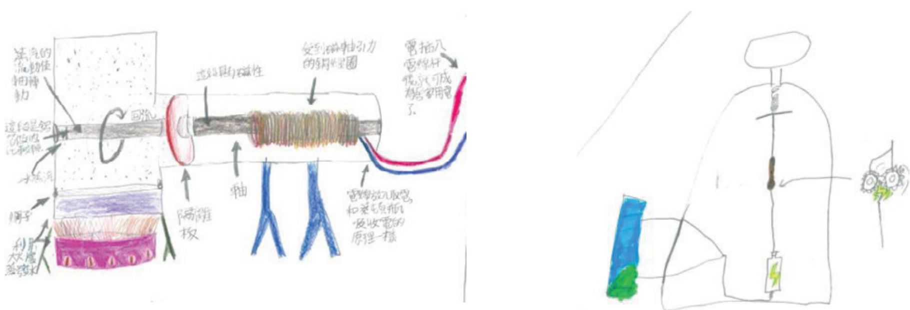


Figure 2. Results of concepts developed from the class-4B using tangible teaching aids

Based on the experimental results obtained from the experimental teaching employed in the classes using tangible and not using tangible teaching aids, tangible aids did not influence the students' understanding of energy transfer or development of concept design. It was, however, very apparent during the detailed sketching of concepts that the class using the tangible aids could grasp mechanical structures more effectively. Although the structures may not be completely accurate, regarding concept completeness, their performance was superior to that of the class that did not use the tangible aids.

6. Conclusions and recommendations for future study

The results of this research employ instruction in energy literacy, guidance for alternative energy, interactions with existing teaching aids, development of concepts connecting energy to daily life, and presentations to encourage students to develop creative concepts that integrate daily life experiences. The study also uses commonly observed devices for saving and creating energy, and develops teaching aids for energy saving and carbon reduction.

1. Through the development and practical operation of the teaching aids, a learning interest could be created so that students enjoyed learning. Interest is the driving force behind study motivation. Lively aids, used to capture the students' interest in learning, could also maintain their attention and increase study effectiveness.
2. This research proposes a problem-based learning model. Using currently available teaching aids combined with energy saving and producing devices seen in daily life, teachers and students could cooperate in developing teaching tool concepts for energy saving and carbon reduction.
3. Regardless of the use or absence of tangible teaching aids, elementary school pupils could understand that there are different methods used to produce energy and to conserve energy. These methods could be related to experiences in daily life.
4. It was noticeable during the student's detailed sketching of their concepts that the class using tangible aids more frequently considered structural mechanisms. Although the mechanisms may not be entirely accurate, regarding concept completeness, their performance was superior to that of the class that did not use the tangible aids.

While analyzing the pre- and post-course assessment questionnaire, the number of participants was considered too small. The questionnaire design and teaching contents were not well correlated. Therefore, in future research, the correlation between the teaching content and questions in the questionnaire must be readjusted. Moreover, additional classes should be included in the experimental instruction. These improvements would enable determining the differences resulting from using or not using tangible teaching aids, particularly regarding student knowledge, attitude, and habitual behavior, from the questionnaire results. In addition, this research did not further evaluate the concepts developed by the students. The next step would involve formulating particular assessment criteria such as innovative creativity, problem solving, and consideration of principles and mechanics. In addition, science teachers of the same grade from different schools should be invited to participate in the evaluation. This might facilitate observing the differences resulting from using and not using tangible teaching aids during concept development.

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